ISBN 0-7743-9000-X

THE ACIDIC PRECIPITATION IN ONTARIO STUDY (APIOS)

AN OVERVIEW: THE CUMULATIVE WET/DRY DEPOSITION NETWORK

(1st Revised Edition)

April, 1984

Report #ARB-164-83-ARSP

Ontario
Ministry of the Environment

ISBN 0-7743-9000-X

THE ACIDIC PRECIPITATION IN ONTARIO STUDY (APIOS)

AN OVERVIEW:
THE CUMULATIVE WET/DRY DEPOSITION NETWORK
(1st revised edition)

Report # ARB-164-83-ARSP
API 005/84

W. H. Chan and D.B. Orr
Air Resources Branch
Ontario Ministry of the Environment
880 Bay Street, 4th Floor
Toronto, Ontario, Canada
M5S 1Z8

and

R. J. Vet*
Concord Scientific Corporation
2 Tippett Road
Downsview, Ontario, Canada
M3H 2V2

April, 1984

APIOS Co-ordination Office
Ontairo Ministry of the Environment
6th Floor, 40 St. Clair Ave. West
Toronto, Ontario, Canada M4V 1P5
Project Co-ordinator: Dr. T. Brydges

©1984 Her Majesty the Queen in Right of Ontario

---

*Current affiliation: Air Quality Branch, Atmospheric Environment Service
4905 Dufferin Street, Downsview, Ontario, M3H 5T4

TABLE OF CONTENTS

		Page
	Preface	iii
1.	INTRODUCTION	1
2.	NETWORK OBJECTIVES	2
	2.1 Cumulative Wet Deposition Network	2
	2.2 Cumulative Dry Deposition Network	2
3.	NETWORK DESIGN	3
4.	NETWORK SITING CRITERIA AND SAMPLING LOCATIONS	4
5.	INSTRUMENTATION	6
	5.1 Cumulative Wet Deposition Network	6
	5.2 Cumulative Dry Deposition Network	9
6.	SAMPLE COLLECTION AND HANDLING TECHNIQUES	11
	6.1 Cumulative Wet Deposition Network	11
	6.2 Cumulative Dry Deposition Network	13
7.	CHEMICAL ANALYSES	14
	7.1 Cumulative Wet Deposition Network	14
	7.2 Cumulative Dry Deposition Network	14
8.	DATA HANDLING AND ANALYSIS	15
	8.1 Cumulative Wet Deposition Network	15
	8.2 Cumulative Dry Deposition Network	15
	REFERENCES	16
Figure 1	Location of APIOS Cumulative Wet/Dry Deposition Network Sites	17
Figure 2	Instrumentation Used in APIOS Cumulative Wet Deposition Monitoring	18

TABLE OF CONTENTS (Cont'd)

		Page
Figure 3	Instrumentation Used in APIOS Cumulative Dry Deposition Monitoring	19
Figure 4	Configuration of Filter Types Used in APIOS Cumulative Dry Deposition Monitoring	20
Table 1	APIOS Cumulative Wet/Dry Deposition Network Site Descriptions	21
Table 2	APIOS Cumulative Wet Sample Laboratory Analyses	22
Table 3	APIOS Cumulative Low-Volume Air Filter Laboratory Analyses	23

APPENDIX 1 APIOS Site Description Questionnaire

PREFACE

Since the last publication of this document (December, 1982), the Acidic Precipitaiton in Ontario Study (APIOS) Cumulative Wet/Dry Deposition Network has undergone a number of changes to ensure that the deposition monitoring program continues to collect the highest quality data it possibly can. Such changes include site relocations, removal of problem sites, addition of new sites and operational procedures which have been established as part of a stringent quality assurance program. This document has been updated to reflect these changes. For a detailed description of the APIOS Cumulative Wet/Dry Deposition Network's structure, operating procedures and quality assurance criteria, refer to the Technical and Operating Manual, (Bardswick, 1983) and the APIOS Quality Assurance Manual (Bardswick, 1984).

1. INTRODUCTION

The phenomenon of acidic precipitation has been recognized as a regional, provincial and international-scale perturbation of the environment. The Air Resources Branch (ARB) of the Ministry of the Environment (MOE) has established two monitoring networks which operate under the auspices of the Acidic Precipitation in Ontario Study (APIOS). The APIOS Cumulative Wet/Dry Deposition Network and the APIOS Event Wet/Dry Deposition Network have been designed to collect data so that a quantification of both wet and dry deposition patterns can be ascertained.

Although the primary concern for both networks is the measurement of deposition, they differ accordingly by the time resolution of their sampling periods. The event (used interchangeably with the term daily) network collects precipitation and air filter samples on a daily basis to investigate the characteristics and to determine the origin of pollutants deposited in these events, i.e. short-term wet and dry deposition patterns. The cumulative network monitors on a 28-day cycle (on a monthly basis from the network's inception in September, 1980 to January 5, 1982), collecting precipitation and air filter samples to measure long-term wet and dry deposition distributions.

Details of the event network are described elsewhere in "The Acidic Precipitaton in Ontario Study (APIOS). An Overview: The Event Wet/Dry Deposition Network" (Chan et al., 1982). This document is available from the Air Resources Branch. No further discussion of this network will be given in this document.

The cumulative deposition network to be presented herein will be described according to its two components under the headings "Cumulative Wet Deposition Network" and "Cumulative Dry Deposition Network" respectively. The exceptions to this format are found in the sections entitled 'Network Design' and 'Network Siting Criteria and Sampling Locations', since a cumulative sampling site must fulfill the same requirements for both wet and dry deposition collection.

2. NETWORK OBJECTIVES

2.1 Cumulative Wet Deposition Network:

The objectives of this network are twofold:

1) To study the chemical composition of cumulative precipitation samples (collected on a 28-day cycle) within the province.

2) To determine the long-term wet deposition distributions of various chemical parameters (both temporally and spatially) across the province.

2.2 Cumulative Dry Deposition Network:

The objectives of this network are also two-fold:

1) To determine the ambient concentration of airborne acid-related pollutants on a cumulative (28-day) basis.

2) To infer dry deposition of these pollutants by using airborne concentrations (obtained by low-volume air filtration) with appropriate deposition velocity values in the relationship:

$$\text{Flux}(\text{ug m}^{-2}\text{s}^{-1}) = 100 \times C\ (\text{ug m}^{-3}) \times V_d\ (\text{cm s}^{-1})$$

Where flux = dry deposition per unit area per unit time

C = 28 day mean concentration

V_d = average deposition velocity

Based on these estimates, the long-term dry deposition distributions of various chemical parameters (both temporally and spatially) across the province can be derived.

3. NETWORK DESIGN

The design of the cumulative network is based on historical data from the Canadian Network for Sampling Precipitation (CANSAP) and on the results of MOE long-range transport computer modelling. The cumulative network was designed to satisfy the following objectives:

1) to provide long-term (seasonal/annual) data to determine deposition fields of acid, sulfur and nitrogen species and trace metals, based on cumulative (28-day) collections,
2) to provide for placement of samplers on spatial scales varying from local to regional to provincial,
3) to give special emphasis to sampling in areas of highest expected and known deposition and/or high susceptibility to acidic deposition.

The sampling program is conducted in five of the Ministry of the Environment's regions (regional offices in parentheses): the Southwestern region (London), encompassing the West-Central region; the Central region (Dorset); the Southeastern region (Kingston); the Northeastern region (Sudbury); and the Northwestern region (Thunder Bay). Because the steepest gradients in deposition exist in Southern Ontario, the density of samplers is highest there. The number of low-volume air samplers in each region is slightly less than those of the wet/dry collectors because of smaller spatial variability in air quality data.

4. NETWORK SITING CRITERIA AND SAMPLING LOCATIONS

Based on the design criteria outlined in the previous section, all MOE regions were inspected for suitable sampling sites. Determining the actual locations involved fulfilling both the aforementioned spatial requirements as well as site-specific requirements. The latter requisites are described in detail here.

The overriding consideration in site selection is the prevention of sample contamination. This is accomplished by locating sampling sites away from local area sources of pollution so that the samplers are regionally representative. In addition, the sampling instruments must be located at a site which has little or no potential for affecting the integrity of the collected samples, i.e. they must be clear of obstructions, and other site-specific sources of contamination nearby must be minimized. The following list summarizes the many sources of contamination that could affect the chemical integrity of samples, both wet and dry:

* urban areas (industrial activity, vehicle emissions, human activity)
* airports
* highways
* trees (obstructions, rain splash, organic debris, throughfall)
* buildings (obstructions, rain splash, emissions)
* unpaved roads (spray, salt, sand, airborne dust, vehicle emissions, snow ploughing, snow blowing)
* sewage treatment plants and aeration lagoons
* cultivated fields and orchards (herbicide and pesticide spraying, fertilizer emissions, airborne dust, organic debris)
* overhead wires
* oil or gas wells
* parking lots
* ground cover (rock, loose soil)
* marshes (emissions, insects)
* gravel pits
* salt or sand piles
* gardens

In addition to the minimizing of sample contamination, siting criteria must also incorporate factors which affect the logistics and operation of samplers. The major considerations are:

* site characteristics (ground cover should be grassy and flat, and as open and cleared as possible)
* avoidance of obstructions (adhere to a minimum "Sampler-to-obstruction" distance of 2.5 times of the obstruction height)
* surrounding vegetation (windbreaks approximately 200 m away improve sampler catch efficiency)
* accessibility (easy access required but must be removed from roads)
* topography (locations near hills and depressions should be avoided)
* electrical supply must be on-site
* safety (must be free from vandalism)
* personnel to regularly maintain sampler and collect samples.

To aid in a comprehensive evaluation of a site, a site criteria checklist (Appendix 1) is used. Acceptance of a site for sampling depends upon the meeting of most (if not all) of the siting criteria. To indicate the importance of proper siting in the APIOS program, site characteristics generally over-ride all other factors.

To date, thirty-six sites have been chosen for automated precipitation samplers by applying the APIOS network siting criteria. Low-volume air samplers are located also at twenty-three of these sites. Some of the sites are located on Ministry of the Environment property while others are on private property. The actual sampling locations are shown in Figure 1 and listed in Table 1.

5. INSTRUMENTATION

5.1 Cumulative Wet Deposition Network:

Each cumulative deposition site is instrumented with an automated deposition collector and a standard APIOS precipitation storage gauge to serve as a primary standard of the total precipitation occurred during a particular 28-day period (see Figure 2). The instrument used is a M.I.C. Type A Deposition Collector (formerly manufactured by Sangamo). The standard manufacturer's instrument has been modified by Air Resources Branch to eliminate or reduce the effect of several problems. A description of the instrument and its major modifications follows.

The principal features of the M.I.C. Type A sampler are:

1) sensor grids (extending out from the body of the collector) for the detection of precipitation,

2) high-density polyethylene collection vessels, with a sufficiently large surface area ($\sim$ 324 cm^2) and

3) a moveable hood (when precipitation comes in contact with the sensor grids, the circuitry of the grids becomes closed, activating the instrument to expose its 'wet' collection vessel and cover its 'dry' side).

The major modifications to the M.I.C. Type A collector are as follows:

1) A pliable silicon gasket is attached to the stainless-steel underside of the moveable hood. Its purpose is to form a tight

seal between the top of the collection vessel and the underside of the hood to minimize evaporative loss of the sample. In addition, the gasket stops contaminants from entering the sample through gaps between the top of the vessel and the underside of the hood. The gasket is also very important for preventing metals contamination of the sample from the hood. Recirculation of sample water can occur as it evaporates inside the bucket, condenses on the underside of the hood, and ultimately drips back into the sample. With no gasket present, the condensate can leach metals from the steel surface and drip them into the bucket. Laboratory testing of this gasket indicates that there is negligible contribution of any chemical constituents of interest from the gasket to the sample.

2) The use of disposable food-grade polyethylene/nylon laminate-type bags (polyethylene bags were used before November, 1982) inserted into collector's buckets to serve as collection containers is a regular feature of the cumulative network. The use of bags as a collection medium is very desirable, primarily due to the reduction of potential contamination and sample handling associated with sample transfers and the elimination of cleaning of collection vessels. Desorption of chemical constitutes from the bag surface has been found to be minimal. Although the bags present pristine environment for sampling precipitation, laboratory analyses have shown that long-term adsorption exists for the trace metals Fe, Al, Cu and Zn which can be recovered by mild nitric acid leaching (Chan et al, 1983).

3) A knife edge collar is attached to the top of the precipitation bucket after the bag is inserted. This clamps the bag in place and gives the sample container a very distinct, narrow edge. This, in turn, reduces rain drop splash and prevents the pick-up of particulates on the edge. The efficient seal between the hood gasket and knife edge serves to minimize evaporation.

4) To improve the efficiency of snow collection, namely by eliminating the blow-out of already collected snow from the collection vessel under high wind conditions, a long bucket and bag for winter precipitation collection has been implemented. Wind tunnel testing at the University of Toronto (Haasz and Solomon, 1980) indicated that the use of a 1 m length collection vessel provides approximately a 4:1 height to diameter ratio, which would optimize the vessel's aerodynamic properties and is sufficient to minimize the snow blow-out effect. To accommodate this longer container, the bottom of the 'wet' side of the MIC Type A collector is cut out and an adjustable support base is attached to the standpost.

5) Standardization of the sensitivity and opening/closing response time of the precipitation collector has occurred so that all samplers across the province react alike to the same type of precipitation. Sensitivity is tested by special sensor grids outfitted with a 220 K (½W) ohm resistor. The timing control has been altered on the collector's integrated circuit so that opening and closing of the hood is set at a two-minute delay ($\pm$30s).

Calculation of the total amount of wet deposition requires a knowledge of the sample chemistry and the total amount of precipitation that falls over the sampling period. Because the efficiency of the sampling instrumentation is less than perfect, the amount of precipitation collected in the sampler is not the true amount. Since most sampling sites do not have manpower on-site to operate standard precipitation gauges on a daily basis, each sampler is then accompanied by an APIOS precipitation storage gauge. This instrument accumulates precipitation over the sampling period and a depth measurement is taken when the sample is collected. To ensure the depth measurement is as accurate as possible, a capping layer of oil is placed in the gauge during the 'summertime' collection period (May to October) to prevent evaporation of the collected precipitation. In the 'wintertime' collection period (November to April) a 60%/40% mixture of methanol/ethylene glycol is placed in the unit to melt the collected snow.

5.2 Cumulative Dry Deposition Network:

In the beginning of the network operation, measurement of dry deposition was in the form of collection of dry fall samples in the dry side bucket of the MIC deposition collector. Similar to the wet deposition collection, polyethylene bags were used. In the summer of 1981, in an attempt to better assess the measurement of dry deposition on a cumulative basis, the APIOS program instituted the use of a low-volume air filtration system. As of June 1983, the dryfall measurement was discontinued entirely. This judgement was based upon the fact that samples collected in polyethylene bags were not representative of dry deposition, particularly for gaseous phase nitrogen and sulfur compounds. The high incidence of gross contamination was also a decisive factor in discontinuing the dryfall measurement. Hence only the low-volume air filtration technique is employed in the network to estimate dry deposition.

The long-term ambient air sampler used in the APIOS network is a Metrex Instrument Ltd AS-2 Low-Volume Air Sampler. The basic features of the instrument are i) a vacuum system controlled by a Gast heavy-duty diaphragm pump, in which the flow rate is controlled by a Dwyer Instruments VFA23 rotameter, ii) a temperature-compensated dry gas meter facilitates accurate monitoring of the flow and, iii) digital counters record associated total volumetric flow and operating time.

The pumping system is used in conjunction with a modified 'Swinnex' two-stage, 47 mm polypropylene filter pack mounted at a 2 m height. The filter pack samples for 28 days (commencing at 0800h local time) at a flow rate of 2.0 litres per minute. Vacuum Jayon tubing connects the filter pack (mounted on a filter pack support plate and enclosed in a protective housing) to the pumping system. The system is oriented toward the dry-side of the co-located M.I.C. collector. The low-volume air filtration set-up is shown in Figure 3.

Within each filter pack there are three types of filters, each type specific for different chemical parameters of interest (Figure 4). The upstream filter is a 47 mm Whatman 40 cellulose filter, which is analysed for water-soluble sulfate, nitrate, ammonium, chloride, sodium, magnesium, calcium, potassium, and the trace metals aluminum, manganese, iron, copper, nickel, lead, zinc, cadmium and vanadium. The Whatman 40 filter is followed by a Membrana (Ghia Division) Corporation 47 mm, 1 um Nylon filter, used for the selective absorption of vapour phase nitric acid. Both filters are loaded in the upstream stage of the filter pack and are in direct contact. The final type of filter used is a pair of 50 mm Whatman 41 cellulose filters impregnated with a potassium carbonate/glycerol solution. This impregnating solution selectively absorbs sulfur dioxide. These filters are loaded in the downstream stage and are also in direct contact with each other.

6. SAMPLE COLLECTION AND HANDLING TECHNIQUES

6.1 Cumulative Wet Deposition Network:

Previously collection of cumulative deposition samples was made on the last-working-day-of-the-month. As of January 5, 1982 the APIOS program began collection of samples on Tuesdays (at 0800 hours local time) every 28 days. On the collection Tuesday, a structured sampling protocol is carried out by an on-site operator. This includes: i) removal of the collected sample, ii) cleaning of the instrument, iii) deployment of a new sample bag, iv) check of instrument performance, v) measurement of storage gauge and vi) recording of observations. A brief synopsis of this protocol is given below.

On changeover dates, the site operator at each station activates the sensor and then stops the hood midway by switching the sampler off. The knife edge collar is then removed from the bucket. The sample is removed by grasping the portion of the bag above the bucket between the thumb and forefinger and lifting upward. As the bag is removed, it is squeezed at the point where the bag folds over the edge of the bucket. Excess air is purged out of the bag, then sealed with a twist tie.

Prior to the installation of a new bag, the instrument is thoroughly cleansed in an effort to minimize the potential of contamination. This requires the operator to wipe the sensor grids and, most importantly, the silicon gasket and retaining collar with ethanol-soaked Kimwipes. A thorough rinsing with deionized-distilled water follows. The parts are then dried with Kimwipes.

To install a new bag, it must be fully expanded and then pushed into the bucket until it nears the bottom. The top of the bag is slid over the top of the bucket and then pulled down until it extends 4-5 inches down the outside of the bucket (i.e. that portion that has been handled). The retaining collar is then secured around the bag at the top of the bucket. At this point of the procedure, a set of sterilized polyethylene gloves must be put on. The operator must reach inside the bucket and flatten the bag against the inside and the top of the bucket. Extreme precaution is taken not to touch the collection surface with anything except the gloved hand.

After the bag has been changed, a brief check of the operation of the instrument is made. Once turned on, a check to see that the hood moves from the centre of the buckets to cover the wet side (if the sensor grids are dry) is done. Other precautions taken include ensuring that a tight seal between the gasket and the wet side collection vessel exists, activating the sensor grids to check that the hood moves to cover the 'dry' checking the time taken for the hood to return to cover the wet side vessel (the response time should be approximately 2 minutes) and finally, ensuring that the sensor grids are warm to the touch.

The remaining task of the operator is to take an accurate precipitation depth measurement of the precipitation storage gauge. To calculate the amount of rainfall that fell during the collection period, the gauge must be measured at the beginning and end of the collection period, with the difference between measurements representing the fallen precipitation. In the wintertime collection period changes in density of the storage gauge methanol/ethylene glycol mixture must be accounted for, thus it becomes necessary for the operator to record the mixture's temperature at time of measurement.

As part of the APIOS Quality Assurance Program, all pertinent information regarding the sample itself is noted on an operator field sheet that accompanies each sample or in instrument and operator log-books on site. If inconsistencies in sampler performance or serious problems affecting the sample's integrity exist, the APIOS technician responsible for the site is notified for corrective action.

Samples collected are picked up monthly from the on-site operators by APIOS technicians responsible for the samplers in their area (samples from the more remote sites in Northeastern and Northwestern Ontario are shipped to the nearest regional MOE office). Samples are transported in coolers to a regional MOE office. Samples are visually inspected for organic debris, particulates and leaks, weighed for the determination of sample volume, properly sealed with a heat sealer, and then labelled. Samples are packed in coolers and shipped by courier service to the Laboratory Services and Applied Research Branch of the Ministry in Toronto, arriving the following day still cooled. In Toronto, samples are logged in and stored at $4^{\circ}C$ before chemical analysis.

6.2 Cumulative Dry Deposition Network:

The filter pack samples of this network are collected at the same time as the wet precipitation collection, i.e. on designated dates every 28 days at 0800 hours local time. The sampling protocol is as follows: prior to an upcoming sampling changeover day, an unexposed filter pack is loaded with Whatman 40, Nylon and K_2CO_3-glycerol impregnated Whatman 41 filters, sealed in a 'Whirl-Pak' polyethylene bag, then either shipped or taken to the sampling site. On changeover days, the low-volume sampler is shut-off and the associated flow rate, flow volume and total time sampled are recorded on operator field sheets. The exposed filter pack is covered with a new 'Whirl-Pak' bag, twisted from off the threaded nylon support plate and the bag sealed. The reverse of this procedure is carried out to mount the new unexposed filter pack. The digital counters on the low-volume sampler are reset to zero and the instrument is switched on to commence sampling.

Upon receipt at the regional MOE office, the filter packs are unloaded. The Whatman 40 filter is laid flat and stored in a small Petri container, while the Nylon and Whatman 41 filters are stored in 'Whirl-Pak' bags. All filters are labelled and then submitted to the Laboratory Services and Applied Research Branch for chemical analyses.

7. CHEMICAL ANALYSES

7.1 Cumulative Wet Deposition Network:

All cumulative precipitation samples are analyzed for the following parameters: volume, conductivity, pH, total acidity, $SO_4^{=}$, $N\text{-}NO_3^{-}$, $N\text{-}NH_4^{+}$, Cl^{-}, Ca^{++}, Mg^{++}, Na^{+}, K^{+}, N-TKN (total Kjeldahl nitrogen), TP (total phosphorus), Zn, Fe, Ni, Cu, Pb, Al, Cd, Mn and V. The methods of analysis are given in Table 2.

7.2 Cumulative Dry Deposition Network:

The individual filters are analyzed for both water quality and inorganic trace constituents. The Whatman 40 filters undergo a deionized-distilled water extraction. The extract is split into two equal aliquots, with one portion being analyzed for the metals Al, Mn, Fe, Cu, Ni, Pb, Zn, Cd and V and the cations Ca^{++} and Mg^{++}. The remaining aliquot is analysed for $SO_4^{=}$, $N\text{-}NO_3^{-}$, $N\text{-}NH_4^{+}$, Cl^{-}, Na^{+} and K^{+}. From the nylon filter, $N\text{-}HNO_3$ (as nitrate) is determined and SO_2 (as $SO_4^{=}$) is determined from the impregnated Whatman 41 filters. Methods of extraction and analysis are given in Table 3.

8. DATA HANDLING AND ANALYSIS

8.1 Cumulative Wet Deposition Network:

The reporting of chemical analysis is structured such that laboratory-approved data are entered from the Laboratory Information System (LIS) into the Ministry's Sample Information System (SIS) data base. A particular submission's supporting field data are merged with the corresponding chemical data. Before the results are finalized, the data are screened according primarily to ionic balance testing, exceedance of range tests, and Dixon-ratio statistical testing (comparison of chemical values for designated geographical regions over the same time interval). Validation flags may be appended to individual analytical results to indicate failure of these tests.

Analysis of the data involves the calculation of cumulative wet deposition rates as the product of pollutant concentration times the true precipitation depth. Reports of cumulative concentration and deposition data listings annual statistics and interpretations are published on a regular basis.

8.2 Cumulative Dry Deposition Network:

Data for dry deposition are entered into the database in the same manner as that of wet data. Anomalous data are flagged by various office comments.

These data are screened primarily by exceedance of range tests. Reports similar to those of wet samples are published on a regular basis.

REFERENCES

Bardswick, W.S., The Acidic Precipitation in Ontario Study - Technical and Operational Manual, April 1983.

Bardswick, W.S., Acidic Precipitation in Ontario Study Quality Assurance Manual, 1984.

Chan, W.H., D.B. Orr and R.J. Vet. The Acidic Precipitation in Ontario Study- "An Overview: The Event Wet/Dry Deposition Network", Air Resources Branch Report No. ARB-11-82-ARSP, July 1982.

Chan, W.H., F. Tomassini and B. Loescher, "An Evaluation of Sorption Properties of Precipitation Constituents on Polyethylene Surfaces", Atmoshperic Environment, 17(9), 1779-1785 (1983).

Haasz, A.A. and D. Solomon. Wind Tunnel Simulation Studies of Snow Collector Gauges, Institute for Aerospace Studies, Univesity of Toronto, May 1980.

AR36-10

FIGURE 1

LOCATION OF APIOS CUMULATIVE WET/DRY DEPOSITION NETWORK SITES

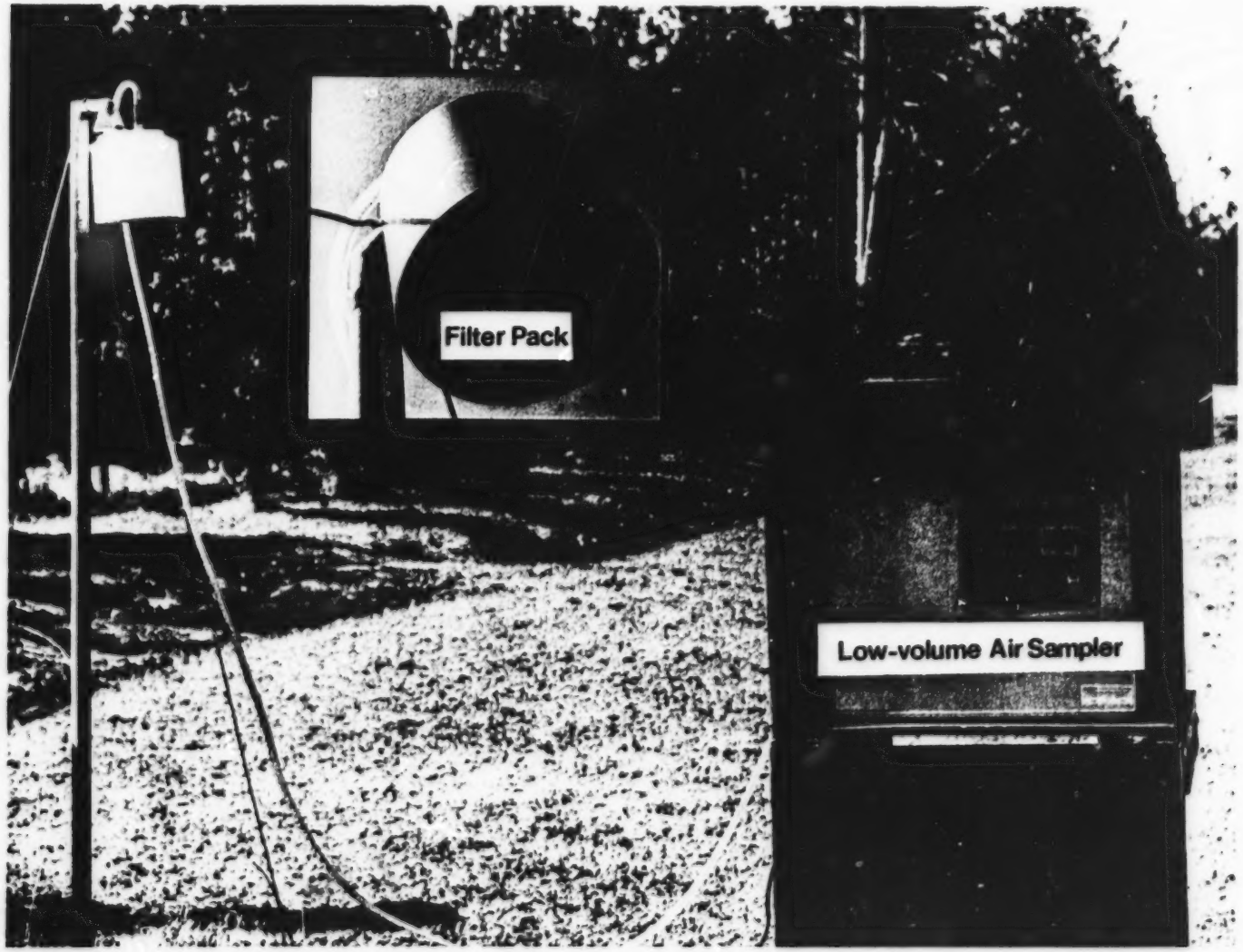
1. Colchester
2. Merlin
3. Pt. Stanley
4. Wilkesport
5. Alvinston
6. Huron Park
7. Waterloo
8. Palmerston
9. Shallow Lake
10. Milton (removed March 1984)
11. Uxbridge
12. Coldwater
13. Campbellford
14. Cloyne (replacing Kaladar, June 1983)
15. Smith's Falls
16. Dalhousie Mills
17. Golden Lake
18. Wilberforce
19. Whitney
20. Dorset
21. McKellar
22. Mattawa
23. Killarney
24. Bear Island
25. Gowganda
26. Azure Lake (replacing Ramsey, June 1983)
27. Moonbeam
28. Attawapiskat (removed, February 1984)
29. Winisk
30. Geraldton (replacing Nakina, August 1983)
31. Dorion
32. Quetico Centre
33. Lac la Croix
34. Experimental Lakes Area
35. Ear Falls
36. Pickle Lake
37. Turkey Lake
38. Otter Island

FIGURE 2:

INSTRUMENTATION USED IN APIOS CUMULATIVE WET DEPOSITION MONITORING

FIGURE 3:

INSTRUMENTATION USED IN APIOS CUMULATIVE DRY DEPOSITION



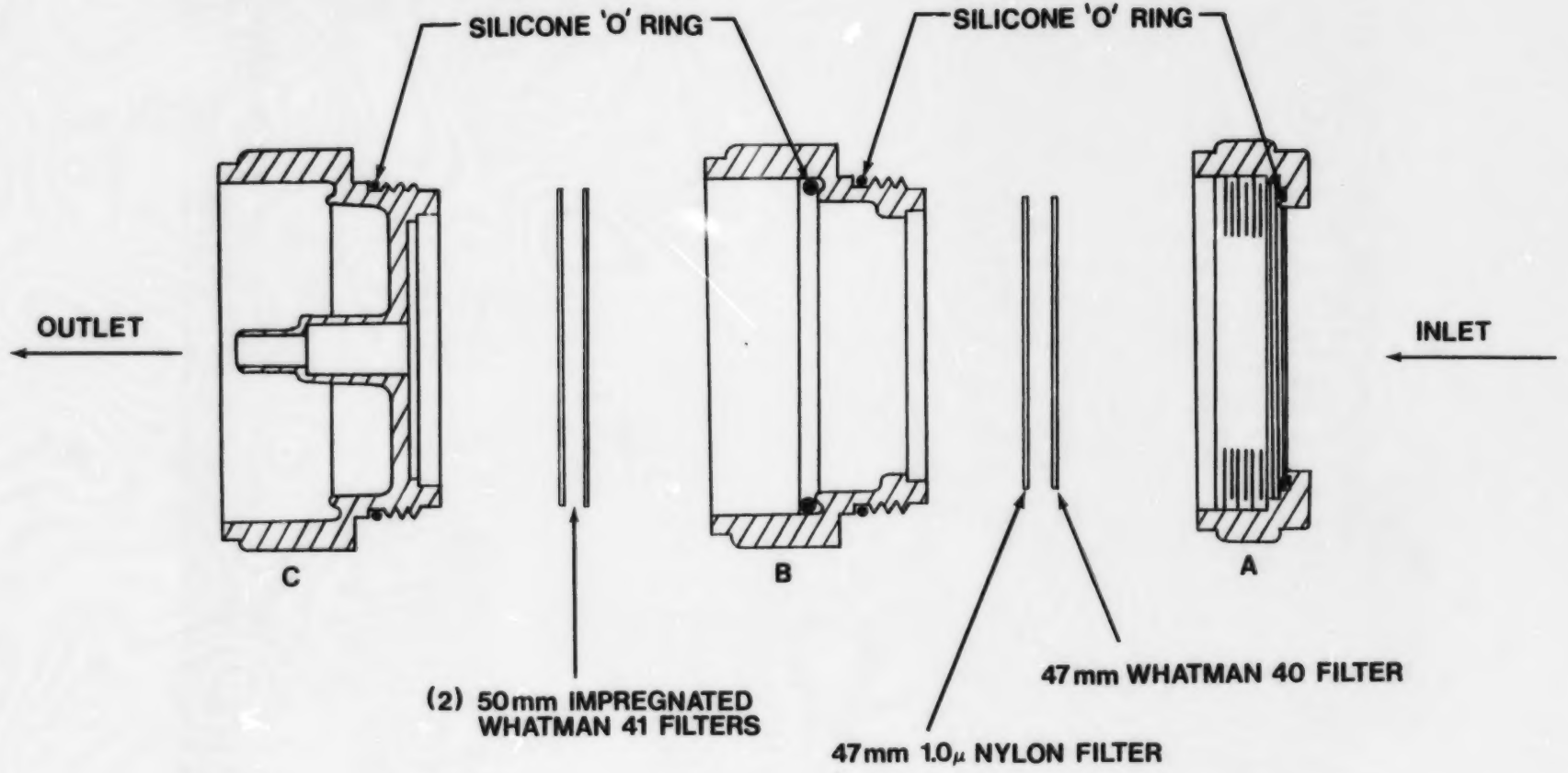


FIGURE 4:

CONFIGURATION OF FILTER TYPES USED IN APIOS CUMULATIVE DRY DEPOSTION MONITORING

TABLE 1

APIOS CUMULATIVE WET/DRY DEPOSITION NETWORK SITE DESCRIPTIONS

MOE REGION	STATION NAME	STATION NUMBER	INSTRUMENTATION	ELEVATION (m above MSL)	LATITUDE (North)	LONGITUDE (West)	UTM GRID CO-ORDINATES (Northing)	(Easting)
Southwestern	Colchester	1041	MIC/Low-Volume Air	183	41°59'15"	82°55'41"	4650000	340300
	Merlin	1051	MIC	191	42°14'47"	82°13'30"	4676400	398950
	Pt. Stanley	1061	MIC/Low-Volume Air	213	42°40'22"	81°09'55"	4724050	486700
	Wilkesport	1071	MIC/Low-Volume Air	183	42°42'11"	82°21'13"	4728350	389150
	Alvinston	1081	MIC	221	42°49'36"	81°50'04"	4942000	431550
	Shallow Lake	1091	MIC/Low-Volume Air	229	44°34'54"	81°05'24"	4936200	492850
	Palmerston	1101	MIC/Low-Volume Air	389	43°48'19"	80°54'12"	4850050	507750
	Huron Park	1191	MIC	250	43°17'28"	81°30'03"	4793000	459350
	Waterloo	2021	MIC	343	43°28'39"	80°35'09"	4813750	533500
Central	Dorset	3011	MIC/Low-Volume Air	320	45°13'26"	78°55'52"	5009650	662400
	Uxbridge	3061	MIC/Low-Volume Air	244	44°12'46"	79°12'38"	4896800	643000
	Wilberforce	3071	MIC	396	45°00'54"	78°12'58"	4988150	719400
	Campbellford	3081	MIC/Low-Volume Air	175	44°17'28"	77°47'33"	4907600	277150
	Coldwater	3101	MIC	280	44°37'31"	79°32'08"	4942200	615900
Southeastern	Smith's Falls	4061	MIC/Low-Volume Air	122	44°56'41"	75°57'48"	4977100	423950
	Dalhousie Mills	4071	MIC/Low-Volume Air	69	45°19'00"	74°28'13"	5018100	541550
	Golden Lake	4081	MIC/Low-Volume Air	160	45°36'48"	77°12'03"	5053200	328400
	Cloyne	4151	MIC/Low-Volume Air	259	44°49'09"	77°11'45"	4964750	327100
Northeastern	McKellar	5011	MIC/Low-Volume Air	244	45°30'57"	79°55'19"	5040600	583950
	Killarney	5021	MIC/Low-Volume Air	183	45°59'26"	81°29'18"	5092900	462200
	Mattawa	5031	MIC/Low-Volume Air	198	46°16'45"	78°49'19"	5127150	667800
	Bear Island	5041	MIC	305	46°58'22"	80°04'40"	5202400	570350
	Gowganda	5061	MIC/Low-Volume Air	343	47°39'04"	80°46'32"	5277300	516600
	Moonbeam	5071	MIC/Low-Volume Air	244	49°19'16"	82°08'46"	5463600	416650
	Whitney	5091	MIC	412	45°32'21"	78°15'35"	5045950	713950
	Turkey Lake	5141	MIC/Low-Volume Air	472	47°03'15"	84°24'00"	5214250	696750
	Azure Lake	5151	MIC	244	47°28'12"	81°52'30"	5257650	434250
Northwestern	Dorion	6011	MIC/Low-Volume Air	244	48°50'33"	88°36'45"	5410800	382150
	Ear Falls	6031	MIC/Low-Volume Air	350	50°38'31"	93°13'13"	5609800	484150
	Pickle Lake	6041	MIC/Low-Volume Air	360	51°27'41"	90°12'04"	5704800	694550
	Lac la Croix	6061	MIC	368	48°21'14"	92°12'32"	5355900	558400
	Quetico Centre	6071	MIC	420	48°44'24"	91°12'08"	5399750	632100
	E.L.A.	6091	MIC	123	49°39'22"	93°43'28"	5500950	447350
	Winisk	6101	MIC	9	55°12'	85°08'	NA	NA
	Otter Island	6111	MIC/Low-Volume Air	198	48°05'39"	86°04'00"	5328900	569500
	Geraldton	6121	MIC /Low-Volume Air	351	49°48'05"	86°46'00"	5516300	516750

TABLE 2

APIOS CUMULATIVE WET SAMPLE LABORATORY ANALYSES

PARAMETER	ANALYSIS METHOD	DETECTION LIMIT ($mg\ l^{-1}$)
pH (for H_f* determination)	Radiometer pH meter and Ingold combination pH electrode	0.01 pH units
Total Acidity (for H_t+ determination)	NaOH titration to pH 8.3; results presented as mg $CaCO_3\ l^{-1}$	0.01
	Gran titration: NaOH titration to a series of inflection points; results presented as ug l^{-1} as H^+	0.01
Conductivity	Radiometer conductivity cell and meter	Depends upon range
$SO_4^=$	Ion Chromatography	0.05
$N\text{-}NO_3^-$	Ion Chromatography	0.01
Cl^-	Ion Chromatography	0.01
$N\text{-}NH_4^+$	Automated phenate-hypochlorite colorimetry	0.002
Ca^{++}	Flame Atomic Absorption	0.01
Na^+	Flame Atomic Absorption	0.005
K^+	Flame Atomic Absorption	0.005
Mg^{++}	Flame Atomic Absorption	0.005
N-TKN	Automated phenate-hypochlorite colorimetry	0.0045
TP	Ammonium molybdate-ascorbic acid colorimetry	0.004
Zn	Flame Atomic Absorption	0.002
Fe	Flameless Atomic Absorption	0.001
Ni	Flameless Atomic Absorption	0.001
Cu	Flameless Atomic Absorption	0.001
Pb	Flameless Atomic Absorption	0.001
Al	Flameless Atomic Absorption	0.005
Cd	Flameless Atomic Absorption	0.0001
Mn	Inductively Coupled Plasma	0.001
V	Flameless Atomic Absorption	0.002

* H_f - Free hydrogen ion concentration
+ H_t - Total hydrogen ion concentration

TABLE 3

APIOS CUMULATIVE LOW-VOLUME AIR FILTER LABORATORY ANALYSES

PARAMETER	FILTER TYPE	EXTRACTION METHOD	ANALYSIS METHOD	DETECTION LIMIT (ug per filter)
Zn	Whatman 40	20 minute ultrasonic bath in 50 ml deionised/distilled water	Atomic Absorption Graphite Furnace	0.100
Fe	Whatman 40	Same as above	Atomic Absorption Graphic Furnace	0.050
Ni	Whatman 40	Same as above	Atomic Absorption Graphic Furnace	0.050
Cu	Whatman 40	Same as above	Atomic Absorption Graphic Furnace	0.050
Pb	Whatman 40	Same as above	Atomic Absorption Graphic Furnace	0.050
Al	Whatman 40	Same as above	Atomic Absorption Graphic Furnace	0.250
Cd	Whatman 40	Same as above	Atomic Absorption Graphic Furnace	0.005
Mn	Whatman 40	Same as above	Atomic Absorption Graphic Furnace	0.050
V	Whatman 40	Same as above	Atomic Absorption Graphic Furnace	0.100
$SO_4^=$	Whatman 40	Same as above	Ion Chromatography	2.50
$N\text{-}NO_3^-$	Whatman 40	Same as above	Ion Chromatography	0.50
$N\text{-}NH_4^+$	Whatman 40	Same as above	Automated phenate-hypochlorite colorimetry	0.100

TABLE 3 (Cont'd)

APIOS CUMULATIVE LOW-VOLUME AIR FILTER LABORATORY ANALYSES

PARAMETER	FILTER TYPE	EXTRACTION METHOD	ANALYSIS METHOD	DETECTION LIMIT (ug per filter)
Cl^-	Whatman 40	20 minute ultrasonic bath in 50 ml deionised/distilled water	Ion Chromatography	0.50
Ca^{++}	Whatman 40	Same as above	Atomic Absorption Spectrophotometry	0.50
Mg^{++}	Whatman 40	Same as above	Atomic Absorption Spectrophotometry	0.250
Na^+	Whatman 40	Same as above	Atomic Absorption Spectrophotometry	0.250
K^+	Whatman 40	Same as above	Atomic Absorption Spectrophotometry	0.250
$N\text{-}HNO_3$	Nylon	15 minute ultrasonic bath in 25 ml 3×10^{-3} N NaOH	Ion Chromatography (as NO_3^-)	0.50
SO_2	Whatman 41	60 minute shaking in 50 ml 0.05% (v/v) hydrogen peroxide; followed by 40 minute ultrasonic treatment; followed by making up to 50 ml with hydrogen peroxide	Ion Chromatography (as $SO_4^=$)	3.35

APIOS SITE DESCRIPTION QUESTIONNAIRE

Date: _____

COMPLETED BY: _____

REVISION NO: _____

Type of Site
(check one)

__ Existing Site (regular network)

__ Potential Site

__ Special Study Site

1. SITE IDENTIFICATION

Cumulative Wet _____ Cumulative Dry _____

Event Wet _____ Event Dry _____

Other (describe) _____

Station Name _____ Station Number _____

MOE Region _____ County _____ Township _____

Latitude ____° ____' ____" Longitude ____° ____' ____" Elevation ____m

UTM Co-ordinates E N

Name of Primary Operator _____

Alternate Operator _____

Regional Technician _____

Mailing Address (Primary Operator)

_____

_____

_____

Phone (Primary Operator) _____/_____ (Res) ____/_____ (Bus)

Phone (Alternate Operator) _____/_____ (Res) ____/_____ (Bus)

Nearest APIOS Site Cumulative: Station Name _____

Distance _____ km

Event: Station Name _____

Distance _____ km

cont'd

2. **LIST OF INSTRUMENTATION** (if applicable)

1) Instrument Type: _____

Cumulative Wet: _____ Cumulative Dry: _____

Event Wet: _____ Event Dry: _____

Other (describe): _____

Manufacturer: _____ Model #: _____

2) Instrument Type: _____

Cumulative Wet: _____ Cumulative Dry: _____

Event Wet: _____ Event Dry: _____

Other (describe): _____

Manufacturer: _____ Model #: _____

3) Instrument Type: _____

Cumulative Wet: _____ Cumulative Dry: _____

Event Wet: _____ Event Dry: _____

Other (describe): _____

Manufacturer: _____ Model #: _____

1) Standard Gauge Type _____

2) Standard Gauge Type _____

Other _____

_____

_____

_____

cont'd

3. SITE LOGISTICS

1) Is road access to site in summer: _____ good _____ fair _____ poor?

winter: _____ good _____ fair _____ poor?

2) Type of road surface? (dirt, gravel, oiled, paved) _____

3) How far is the primary collector from road access? _____ m

4) If necessary, how close can a vehicle approach the collector? _____

5) If no road access to site, how is site reached? (plane, snowmobile) _____

6) What is the available electrical power at site? _____

Volts _____ Amps _____ No. of circuits _____

7) Is the circuit on a: Receptacle GFIC _____

Circuit Breaker GFIC _____

No GFIC _____

Battery _____

8) What is the distance from collector receptacle (or proposed site) to circuit panel?

_____m

9) What are the number of power failures per month? _____

per year? _____

10) Are there any other logistical problems which prevent the sampling site being easily approached or operated?

(locked gate, guard dog, flooding in spring?)

_____

_____

_____

cont'd

4. TOPOGRAPHY AND LAND USE

1) Ground slope at site: _____ %

2) Ground cover within 15 m of sampler (grass, scrub, gravel, sand, soil)

_____

3) Soil type within 10 m of site (sand, topsoil, clay, rocky)

_____

Soil type within 500 m of site (sand, topsoil, clay, rocky)

_____

4) Land use % near site, within 1 km/10 km

% Cultivated _____/_____

% Orchard _____/_____

% Lawn _____/_____

% Pasture _____/_____

% Forest _____/_____

% Water _____/_____

% Other (describe) _____/_____

Type of Cultivated crop(s) _____

Forest types within 1 km of site _____

5) What types of windbreaks are within 200 m of primary sampler (buildings, trees, hills) _____

6) Indicate any windbreaks within 200 m of primary sampler (Mark what quadrants of the compass have a windbreak)

cont'd

7) Prevailing wind direction during event (according to Operator)

Winter _____ °

Summer _____ °

8) Comment on local topography (i.e. flat, hilly, river, basin, etc.)

_____

_____

_____

_____

_____

_____

9) Cultivated Land Use

Type of Crop	Type of Herbicide or Insecticide Used and when applied	Type of Fertilizers and when applied	Future Crops	Distance to Crops	Direction to Crops

cont'd

10) Any planned land use in future? _____

_____

_____

11) In winter is there any evidence of drifting snow? _____

12) Tall objects near sampler:

i) Trees _____ (species) Max Height _____ m

Distance _____ m Direction _____ o

ii) Buildings _____ (type) Height _____ m

Use _____ Type of Heating _____ Distance _____ m

Direction _____ o

iii) Other (overhead wires, telephone poles, hedges)

A) Object _____ Height _____ m

Direction _____ o Distance _____ m

B) Object _____ Height _____ m

Direction _____ o Distance _____ m

C) Object _____ Height _____ m

Direction _____ o Distance _____ m

D) Object _____ Height _____ m

Direction _____ o Distance _____ m

Comments _____

_____

_____

_____

_____

_____

_____

5. HUMAN ACTIVITY

1) Large highways (expressways): Distance _____ (Km, m)

Route # _____ Direction from Sampler _____

2) Other paved roads: Distance _____ (Km, m)

Direction from sampler _____

traffic: Heavy _____, Medium _____, Light _____

3) Unpaved road: Distance _____ (Km, m)

Direction from sampler _____

traffic: Heavy _____, Medium _____, Light _____

Surface (dirt, gravel, oiled) _____

4) Parking lot: Distance _____ (Km, m)

Direction from sampler _____

Unpaved _____ Surface material _____ Use: Continuous _____

5) Lake/river or rail traffic: Distance _____ (Km, m)

Direction from sampler _____ barge _____

lake steamer _____ rail _____

traffic: Heavy _____, Medium _____, Light _____

6) Snow clearing procedures:

Type of surface (road, parking log, hwy, walkway)	Surface distance from sampler	Direction from sampler	Snow Control (plowed, sanded, blown, salted- with what?)

7) Airport(s): Distance _____ (Km, m)

Direction from sampler _____ Name _____

traffic: Heavy _____, Medium _____, Light _____

traffic type: _____

8) Stationary sources:

Power plant(s): Distance _____ (Km, m)

Direction from sampler _____ Fuel (gas, coal) _____

Electrical Capacity _____ (KW_e, MW_e)

Light industry: Name _____ Distance _____ (km)

Direction from sampler _____ Product _____

Heavy industry: Name _____ Distance _____ (km)

Direction from sampler _____ Product _____

9) Other sources: Significant agricultural operations:

Distance _____ (Km, m)

Direction from sampler _____

Other (please describe) _____

_____

Distance _____ (Km, m)

Direction from sampler _____

Other could include - gravel pits, sewage lagoons, marshes, MTC,

Salt or Sand piles - (see Topographical Maps)

cont'd

10) Effects from local cities, towns, or villages (population)

A	100,000
B	10,000
C	5,000
D	1,000

NAME	POPULATION (letter code)	DISTANCE	DIRECTION	TYPES OF POLLUTION SOURCES

6. SITE SUMMARY

List deviations from site criteria and all advantages and disadvantages of this site.

(use reverse side if necessary)

7. SITE LOCATION

1) A topographic map (Scale 1:50,000) indicating sample site with a Red X.

   - arrows on top map indicating best approach from nearest "MAIN" Highway.

   - indicate with red dots any major sources of pollution of contamination (industry, gravel pits, towns)

2) A concise description on how to reach this site. (below)

8. SITE DIAGRAM

1) Notable Items (mark all distances)

1. North
2. Direction of prevailing winds
3. Windbreaks
4. Roads (with names)
5. Parking lots
6. Buildings (indicate type of heating)
7. Potential contamination sources
8. Ground cover (grass, scrub, soil, sand)
9. Trees/hedges/marshes
10. Obstructions (include height): poles, towers
11. Topography
12. Water
13. Crops/gardens
14. Paths (foot, snowmobile, ski)
15. Location of existing hydro facilities
16. Position of sampler(s)
17. Nature of soil (rocky, sandy, clay)

2) Legend

Coniferous trees (include height, H=)

Deciduous trees (include height, H=)

Wooden fencing (include height, H=)

Wire fencing (include height, H=)

Grass

Direction of ground slope

Bushes/hedges (include height, H=)

Buildings (height and heating)

Railway tracks

9. **SITE PICTURES** (Indicates site name, compass point and date of photograph on back of all slides)

1) Two pictures are to be taken so as to best include all sampling instrumentation on site. If possible take pictures 90° apart from each other. Indicate on Site Diagram as P1 and P2 where the pictures were taken from. Also, identify each picture on a list of photographs.

2) Take four pictures showing the area surrounding the site. These should be taken at four compass points from just behind primary sampler facing in the direction of the compass point.

3) Special pictures showing nearby potential sources of contamination (e.g. salt pile) that may affect the site are to be taken. These should be indicated, if possible, on a site diagram as SP1, SP2, etc. with a description of the picture on the back of the print.

LIST OF PHOTOGRAPHS

#	Direction Facing	Comments